Investigation on Adopting Control Measures for Off-Road Equipment Fuel Tanks (OREFT)

Monitoring and Laboratory Division
Planning and Technical Support Division
Mobile Source Control Division
California Air Resources Board

November 9, 2000

Highlights and Emission Reductions from the Portable Fuel Container Spillage Control Measure

- Automatic closure
- Single opening
- Automatic shut-off
- Permeation standard (0.4 grams/gallon/day)

Year	Uncontrolled ROG Emissions (tons/day)	Controlled ROG Emissions (tons/day)	ROG Reductions (tons/day)	Percent Reduction (%)
1998	93.4			
2007	101.5	25.3	76.2	75.1
2010	103.6	25.8	77.8	75.1

Evaporative Emissions Inventory of Gasoline Powered Small Off-Road Equipment (SORE)

- Definition
- Evaporative Emissions Processes
- Parameters Needed to Calculate Emissions Inventory
- Sources
- Emissions Inventory

Gasoline Powered Small Off-Road Equipment

- All equipment powered by <25 hp SI Engine excluding recreational vehicles
- 2 stroke and 4 stroke engines included

Gasoline Powered Small Off-Road Equipment

- Included in following categories of the OFFROAD model:
- Agricultural Equipment
- Airport Ground Support Equipment
- Construction
- Lawn and Garden Equipment
- Commercial Equipment
- Industrial Equipment
- Logging Equipment
- Transport Refrigeration Unit

Gasoline Powered Small Off-Road Equipment

- Examples of the Common Equipment:
- Lawn mowers
- Trimmers
- Leaf blowers
- Chainsaws
- Generator sets

Processes That Effect Evaporative Emissions

- Hot Soak - Emissions occur following engine shutdown. Fuel temperature is higher than ambient.
- Diurnal - Emissions occur when stored fuel vapors escape to the outside of a fuel tank,hose or any possible openings while the equipment is subject to daily ambient temperature variations.
- Running - Emissions occur when the the equipment is being used. (No emission estimates are available)
- Permeation - These emissions (subset of diurnal) are produced when fuel molecules infiltrate the saturated walls of fuel tank or hoses.

Parameters Needed to Estimate Evaporative Emissions Inventory

- Population
- Equipment fuel tank size and average fill level between refills
- Frequency of usage
- Emission Factors by process

Data Sources

- Population - OFFROAD model
- Fuel Tank Size - Information from brochures and dealer's web sites
- Average Fuel Tank Volume - Assumed 50% between refills
- Emission Factors - Based on literature search and in-house testing conducted by the ARB staff (Summary of emissions data is provided as Table 1).

Statewide Preliminary Inventory of Evaporative ROG Emissions in 2000 for SORE Category

- Diurnal (including permeation) = 24 tpd
- Hot Soak = 0.5 tpd
- Running = not determined yet
- 7% of the above emissions are from equipment that are being preempted from California's regulations.
- Above estimates are subject to change based on more ongoing testing

Future Testing and Refinements to be Incorporated in the Final Emission Inventory Estimates

- Test data for 2 stroke engines
- Test data for additional 4 stroke engines.
- Temperature profile based on ambient and garage temperature profiles measured during this summer
- Adjustments for the wintertime temperature profiles

Objective of the Off-Road Equipment Fuel Tank Investigation

To reduce ROG evaporative and permeation emissions from off-road equipment by:

- Establishing a cost effective control limit for diurnal emissions

Applicability

- Any proposed control measure would address diurnal emissions on SORE Tier II engines less than 25 horsepower
- The control measure would be aimed at engine and fuel tank manufacturers

Evaporative Emission Control Technologies Evaluated

- Closed fuel system / modified tank
- Tanks vented to carbon canisters
- Tanks filled with expanded metal mesh
- Bladder fuel tanks

Baseline Vented Tank in SHED

Baseline Evaporative Emissions From a Typical Vented Fuel Tank

- One quart Tecumseh tank chosen for its simple geometry and typical size
- Tests were performed on six tanks of the same model
- Emissions measured in SHED using a summertime (65 F- 105 F - 65 F) diurnal temperature profile
- Tank filled with 450 ml of CERT fuel
- Average baseline emissions - 0.500 grams/day

Emissions From a Sealed Tank

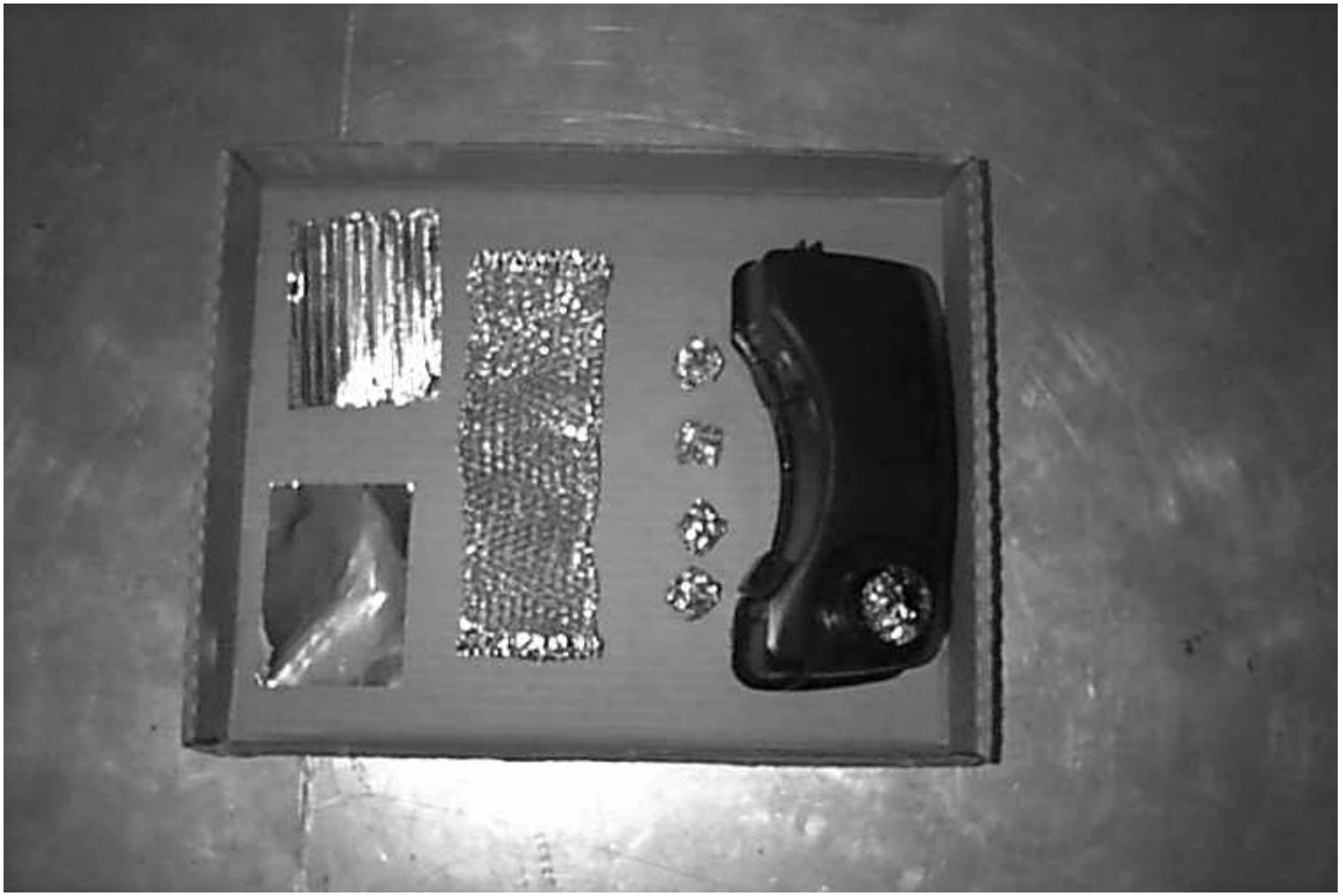
- Tank filled with 450 ml of CERT fuel
- Tank sealed to simulate closed fuel tank
- Average diurnal emissions - 0.033 grams/day
- Emission reduction efficiency - 93.4 %

Tank Vented to Carbon Canister

Emissions from a Tank Vented to a Carbon Canister

- Tank filled with 450 ml of CERT fuel
- Tank vented to carbon canister
- Average Diurnal Emissions - 0.020 grams/day
- Emission reduction efficiency - 96.0 %

Tank Containing Metal Mesh



Emissions From Tank Filled With Expanded Metal Mesh

- Tank filled with expanded metal mesh
- Tank filled with 450 ml of CERT fuel
- Average diurnal emissions - 0.535 grams/day

Tank Configured With Bladder and Sample

Emissions From Tank Containing a Bladder

- Tank filled with 100 ml of CERT fuel
- Average diurnal emissions - 0.139 grams/day
- Emission reduction efficiency - 72.2 %

Baseline and Control Technology Diurnal Data Summary

Test No.	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**	**Mean**	**Std. Dev.**
Vented	0.566	0.443	0.454	0.526	0.517	0.491	0.500	0.04640
Treated/Sealed	0.043	0.033	0.022				0.033	0.01050
Vented to Carbon Canister	0.015	0.024					0.020	0.00636
Containing Metal Mesh	0.375	0.646	0.534	0.598	0.545	0.512	0.535	0.09222
Containing Bladder	0.074	0.203					0.139	0.09122

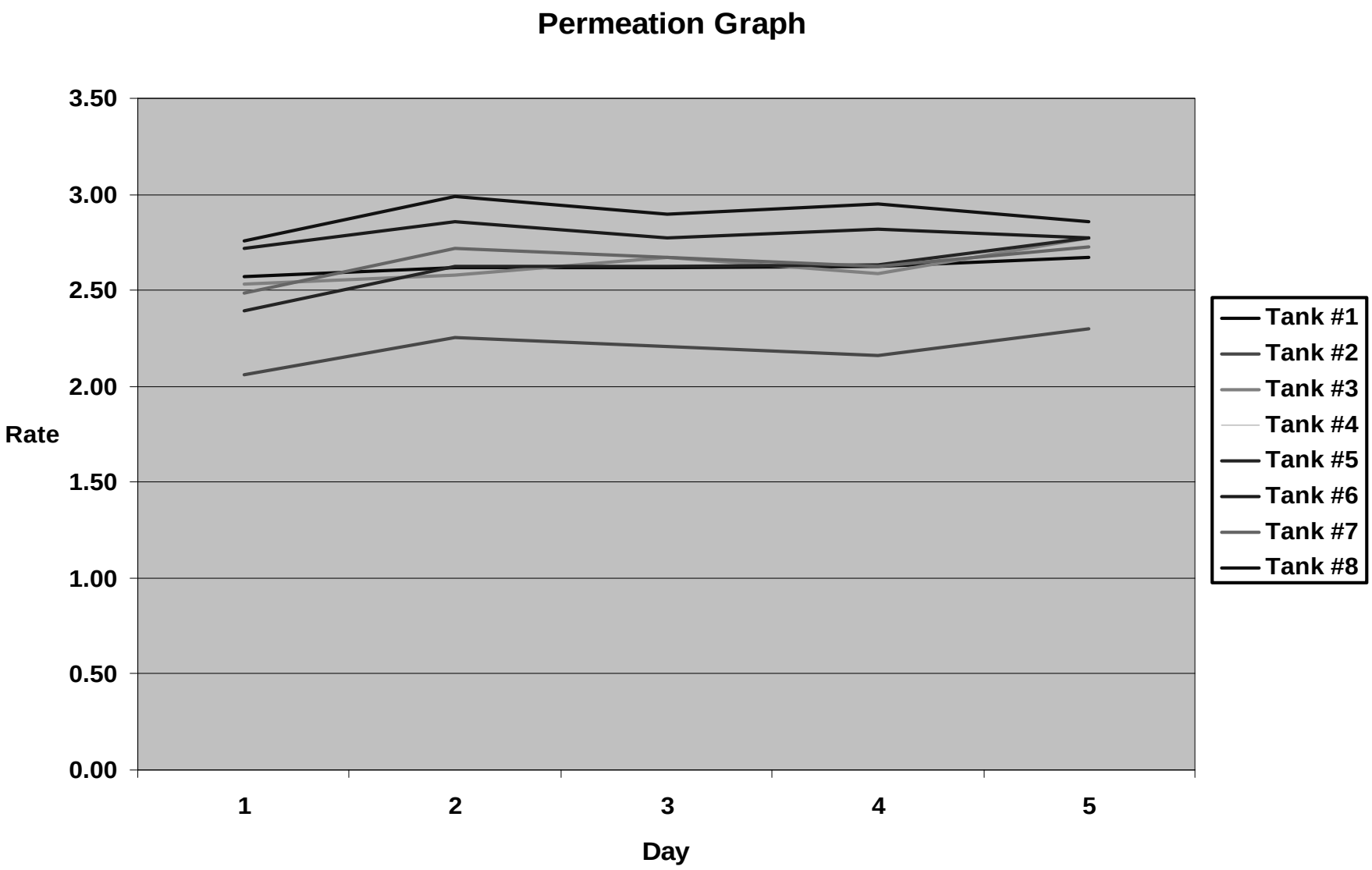
Permeation Control Technologies

- Barrier surface treatments
  - » Sulfonation or fluorination
- New resins (Selar RB™)
  - » Mixed with HDPE
- Co-extruded fuel tank
  - » Multilayer construction using EVOH

Baseline Permeation Emissions from a Typical Fuel Tank

- Testing performed on eight Tecumseh tanks
- Emissions measured with a balance every 24 hours for 5 consecutive soak periods in a SHED at a constant temperature of 80º F
- Average Permeation Emissions - 2.62 grams/gallon/day

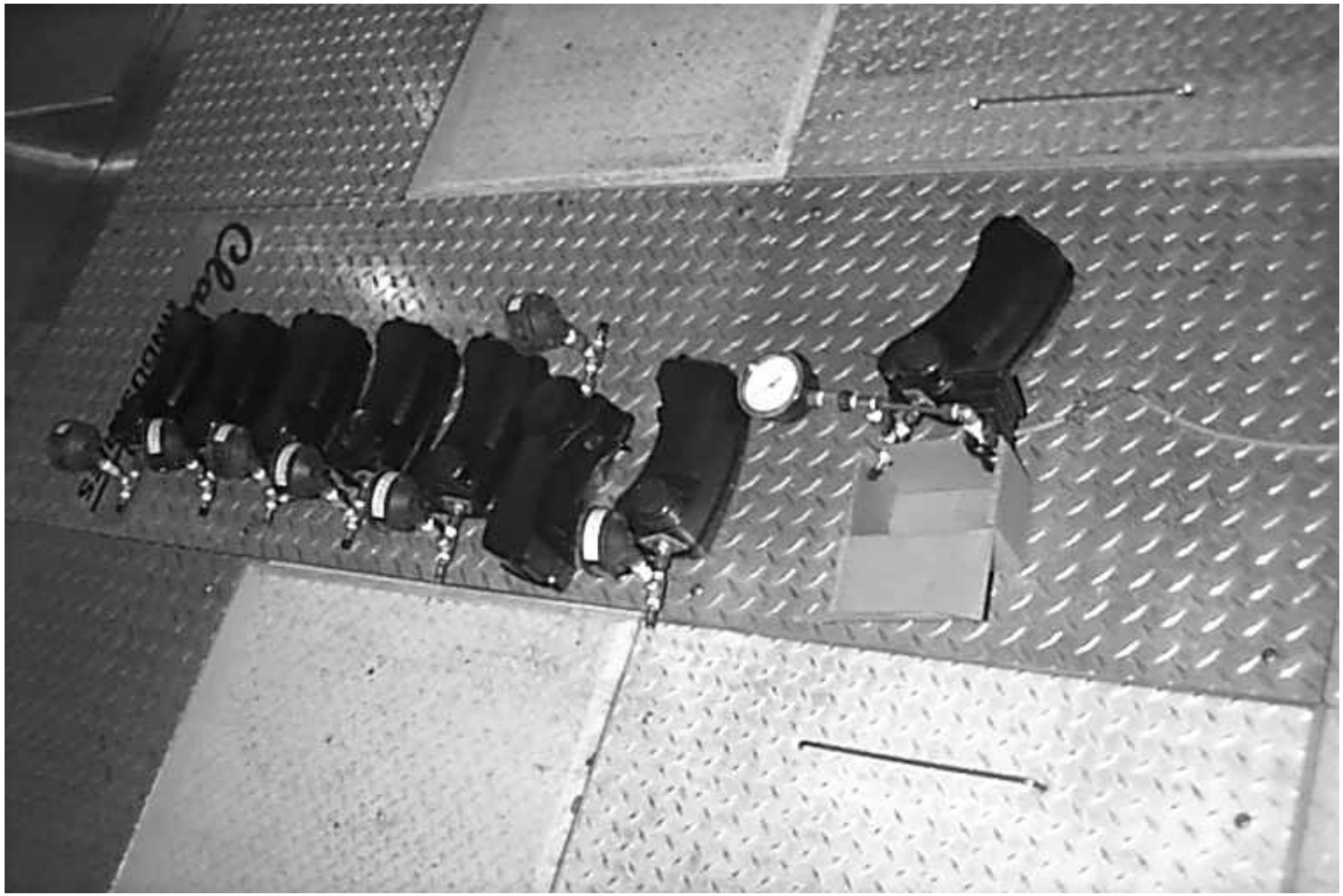
Baseline Permeation Rate Graph



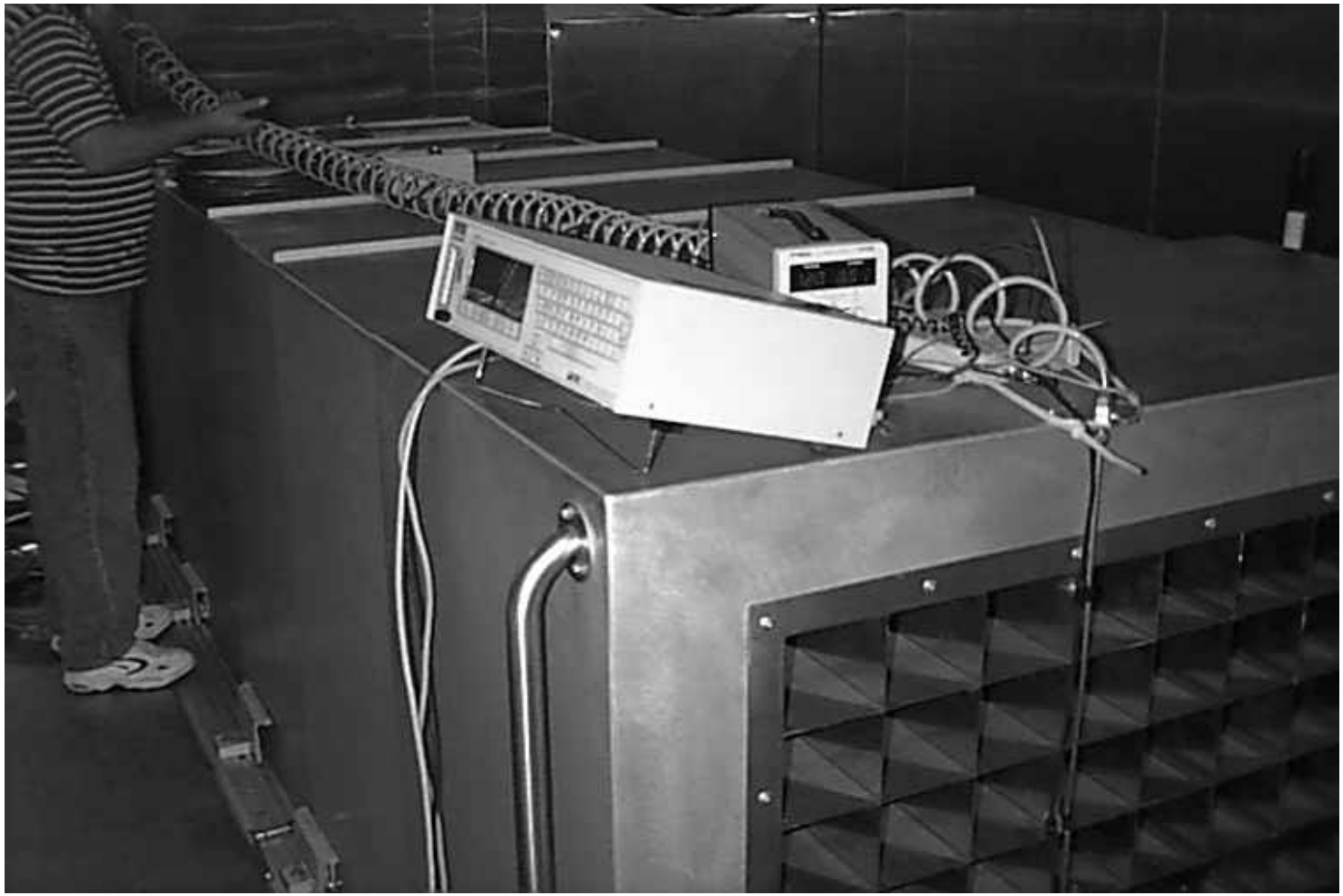
Effect of Pressure on Permeation Emissions

- Testing performed on the eight one quart Tecumseh fuel tanks at (0.0, 2.5, and 5.0 PSI)
- Emissions measured with a balance every 24 hours for 15 consecutive soak periods in a SHED at a constant temperature of 80º F

Pressure Dependency Test Tanks in SHED



Data Logger to Record Pressure

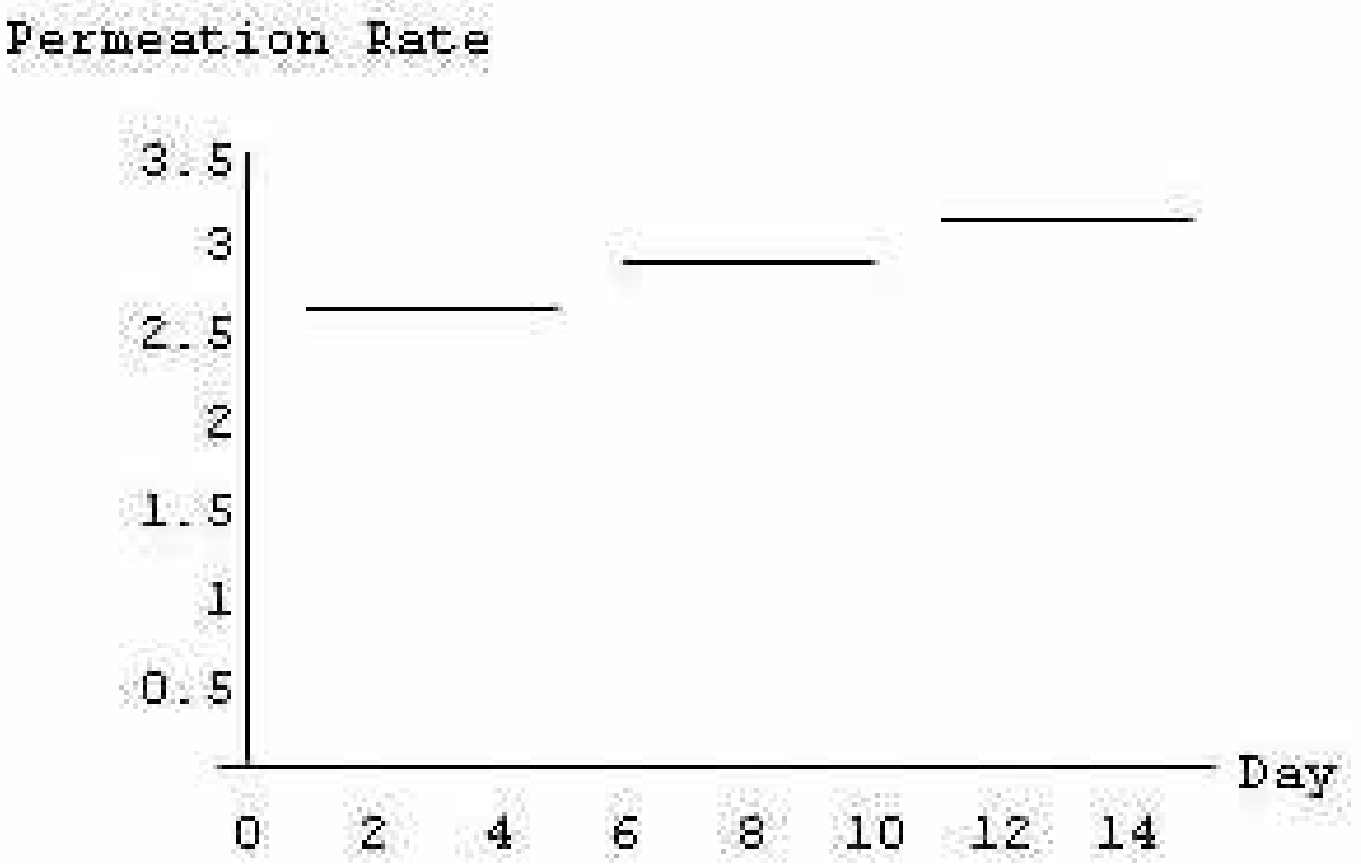


Pressure Dependency Results

- Permeation emissions increase (0.50 grams/gallon/day)

	Avg. Day (1-5) 0.0 PSIG	Avg. Day (6-10) 2.5 PSIG	Avg. Day (11-15) 5.0 PSIG
Mean	2.62	2.88	3.12
Std. Dev.	0.22	0.27	0.26
Upper 95	2.79	3.07	3.31
Lower 95	2.46	2.68	2.93

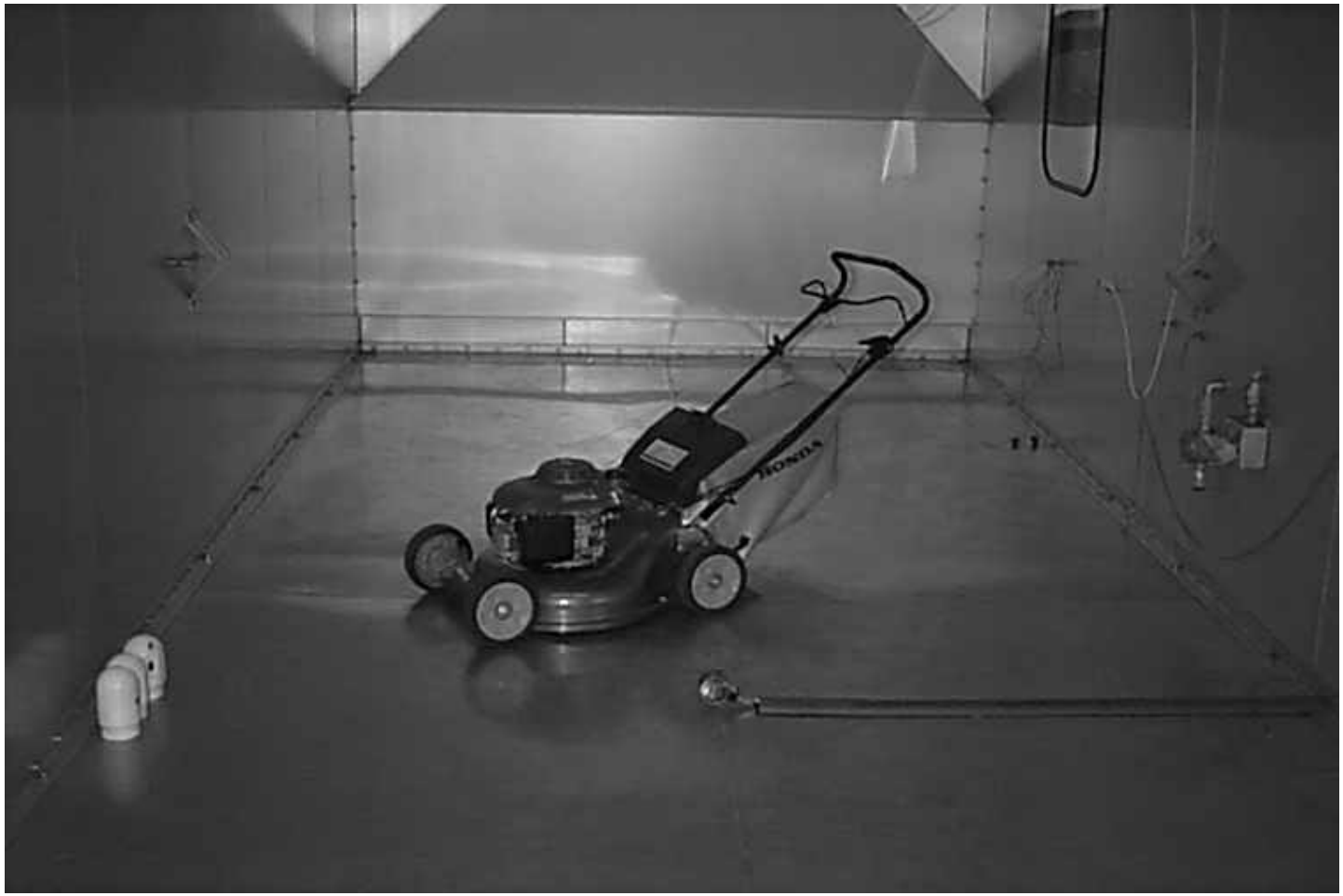
Pressure Dependency Graph
Rates in Grams/gallon/day



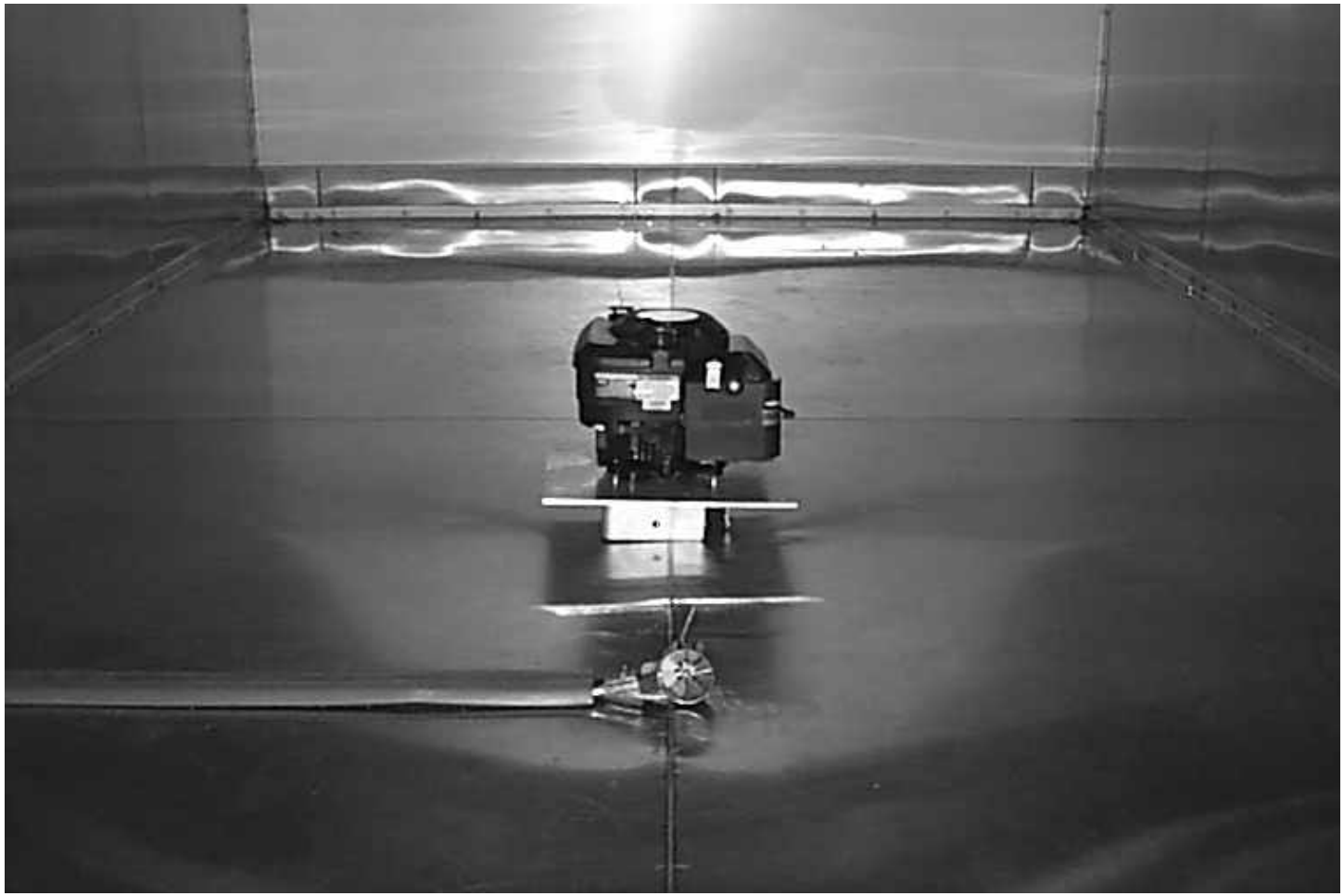
Off-Road Equipment Diurnal Emission Factors

	Honda Mower	Briggs & Stratton Mower	Briggs & Stratton HS Engine	Honda Trimmer
Measured emission factor from complete system	2.665 grams/day	2.737 grams/day	1.759 grams/day	0.787 grams/day
Measured emissions from tank only	0.515 grams/day	1.004 grams/day		0.144 grams/day
EPA Nonroad emission factor	4.0 grams/day	4.0 grams/day	1.8 grams/day	0.54 grams/day

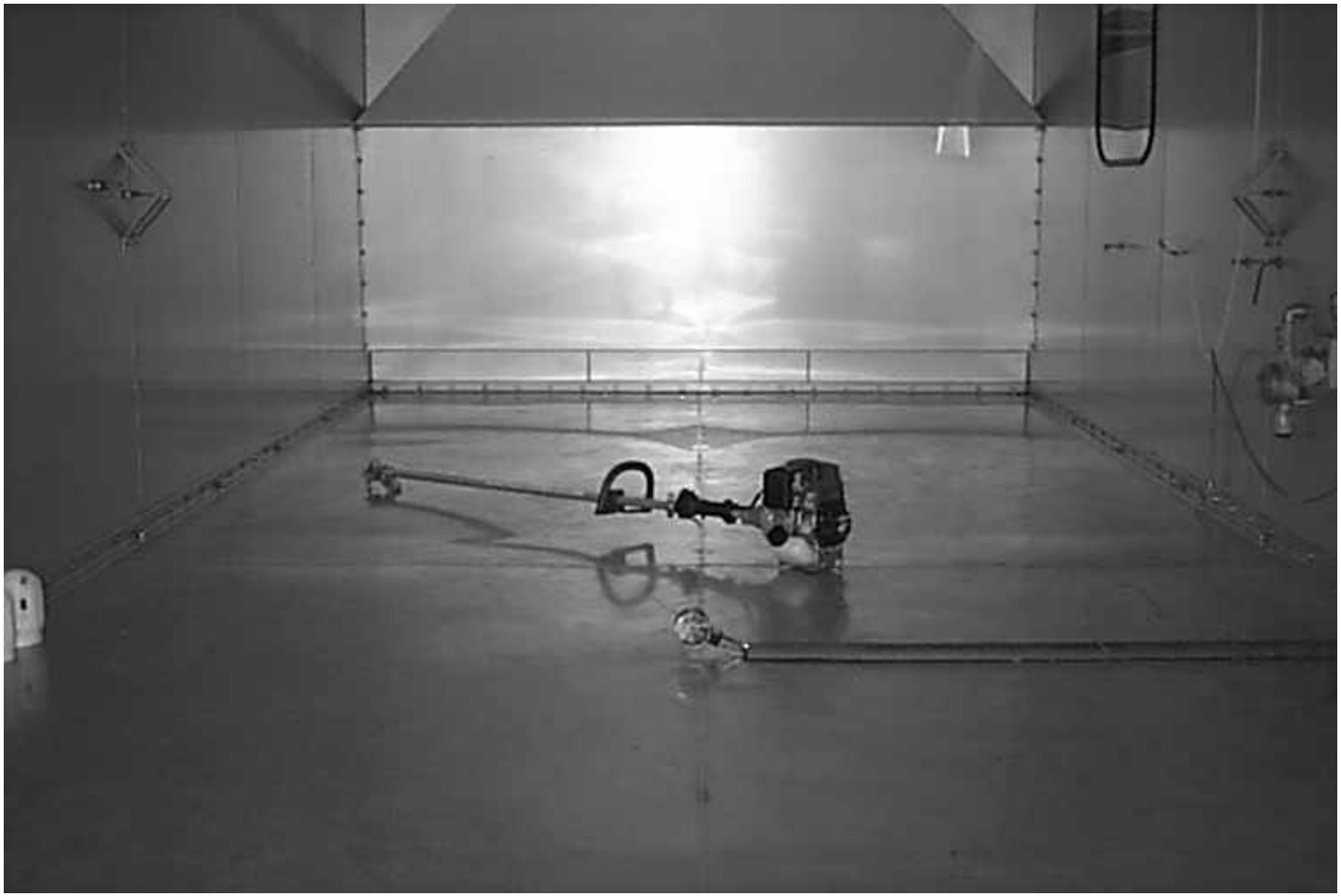
Honda Mower in SHED



Briggs & Stratton Vertical Shaft Engine in SHED



Honda Trimmer in SHED



Additional Testing

- Development of diurnal emission factors for major categories of off-road equipment
- Determination of the vented emissions and permeation rates for a variety of off-road equipment fuel tanks
- Quantification of evaporative losses during refueling
- An evaluation of LPG fueled systems

Significant Milestones

Task	Target Date
Preliminary Testing & Control Strategy Evaluation	*July-October, 2000*
First Workshop	*November , 2000*
Additional Testing	*February, 2001*
Second Workshop	*May, 2001*
Staff Report	*October, 2001*
Board Consideration	*December, 2001*

Questions and Comments?

List of previously noted issues raised by stakeholders

- Industry has not been consulted prior to developing the Off-Road Inventory
- Industry would like the Board to develop and use seasonal emission factors in OFFROAD
- The time frame to take the control measure to the Board is too short
- The Board does not understand the coordination issues between manufacturers and system integrators
- The Board has not fully thought out how the control measure will be implemented
- Fuel tanks may have to be redesigned to be able to withstand the pressures associated with closed systems
- Permeation testing should be performed with ethanol

Contacts and Additional Information

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